

## Nomenclatural updates and a new species of annual *Hydrocotyle* (Araliaceae) from Western Australia

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### Abstract

Perkins, A.J. Nomenclatural updates and a new species of annual *Hydrocotyle* (Araliaceae) from Western Australia. *Nuytsia* 30: 253–277 (2019). This treatment deals with five annual Western Australian species of *Hydrocotyle* L. and is based on the outcomes of a recent molecular phylogenetic study combined with a re-evaluation of schizocarp morphology. *Hydrocotyle perplexa* A.J.Perkins is newly named, *H. intertexta* R.Br ex A.Rich. is reinstated, and the three other species covered are *H. glochidiata* Benth., *H. scutellifera* Benth. and *H. tetragonocarpa* Bunge. Three taxa are placed in synonymy: *H. blepharocarpa* F.Muell. under *H. scutellifera*, *H. pilifera* Turcz. under *H. intertexta* and *H. hispidula* var. *tenella* Benth. under *H. perplexa*. Lectotypes are selected for five of these names, and full descriptions, distribution maps and images are provided for all five species. Details of the history of recognition of these species, and a series of misapplications of names, are also given.

### Introduction

*Hydrocotyle* L. (Araliaceae) is a genus of 35 annual and c. 95 perennial mesophyllous herbs, of which an estimated 58 species occur in Australia (Perkins 2019a). All species have a laterally flattened, dry schizocarpic (bicarpellate) fruit (Perkins 2019b). The annual species are endemic to Australia, and 28 of them are found in Western Australia. Most annual *Hydrocotyle* are ephemeral, often visible above ground for only a few months each year. Species such as *H. alata* A.Rich., *H. callicarpa* Bunge and *H. diantha* DC. are widely distributed in a variety of habitats including coastal and inland swamps, damp depressions in woodlands, margins of inland lakes and moss swards on granitic rocks. Other species are relatively specific to certain habitats; for example *H. hispidula* Bunge and *H. tetragonocarpa* Bunge grow in coastal areas on calcareous sands or limestone; *H. asterocarpa* A.J.Perkins, *H. decorata* A.J.Perkins and *H. spinulifera* A.J.Perkins grow on the margins of inland saltwater lakes; and the aquatic species *H. lemnoides* Benth. grows in the shallows of freshwater swamps.

Taxonomic studies and treatments of Western Australian *Hydrocotyle* (e.g. Bentham 1867; Wheeler 1987; Wheeler *et al.* 2002; Perkins 2017a,b; Perkins & Dilly 2017) have traditionally considered fruit characters to be important in delineating annual species, with the assumption that discrete phenotypes in mericarp shape and surface ornamentation correspond to separate, definable taxa. However, a recent molecular phylogenetic study (Perkins 2019a), with a strong representation of annual *Hydrocotyle*, suggested two cases where fruit polymorphy does occur within species. That study identified two well-supported clades, one comprising annual species with ebracteate flowers, and the other comprising annual and perennial species with bracteate flowers. Within the ‘bracteate clade’, two well-supported

clades were recovered with one clade comprising only perennial species, and the other clade comprising only annual species. Four conclusions of taxonomic consequence in that study were:

1. *Neosciadium* Domin and *Hydrocotyle* are congeneric;
2. Specimens referable to *Hydrocotyle* sp. Hamelinensis (G.J. Keighery s.n. PERTH 02391325) and *H. tetragonocarpa* are conspecific;
3. *Hydrocotyle* sp. Puberula (H. Eichler 22058) and individuals identified therein as *H. scutellifera* Benth. are conspecific;
4. *H. blepharocarpa* F.Muell. requires circumscription to include individuals with glabrous mericarps, incorrectly assigned by some authors to *H. scutellifera*.

Perkins (2019a) dealt only with the lectotypification of *H. glochidiata*, thus, the application and circumscription of various names available for other clades of *Hydrocotyle* still required evaluation. The current paper addresses these issues. It provides full descriptions, notes on typifications, distribution maps and images for the five annual species covered.

## Methods

Updated taxonomic descriptions are based on a comprehensive sample of fertile herbarium voucher specimens housed at PERTH, MEL, NSW and CANB. Vegetative and floral characters were measured from herbarium material using a dissecting microscope and the morphological terminology used in this study follows that of Perkins (2018a–c). Distribution maps for each species were produced from voucher specimen data held at PERTH, MEL, NSW and CANB, using QGIS Version 3.6.2, and they include the Interim Biogeographical Regionalisation for Australia (IBRA) Version 7 boundaries (Department of the Environment 2013). Habitat and phenology data were collected from herbarium labels and field observations. Images of type specimens were viewed via *Global Plants* (<https://plants.jstor.org/>).

## History of species recognition and misapplied names

Collections of the species named herein as *H. perplexa* A.J.Perkins were first made by Robert Brown from King George III Sound [Albany], Western Australia in 1801. Brown assigned the manuscript name '*Hydrocotyle intertexta*' and provided two duplicates, with associated descriptive notes, to French botanist Achille Richard, who formally described this material in his monograph of *Hydrocotyle* (Richard 1820). Brown's syntypes of *H. intertexta* R.Br. ex A.Rich., retained by Richard (now held at P), were part of a mixed gathering of two taxa, the second one represented by specimens held at BM, K and MEL (now attributable to *H. perplexa*). *Hydrocotyle intertexta* was not illustrated in Richard's 1820 monograph and the protologue may have been interpreted as also encompassing the morphology of the duplicates held at K and BM. The key distinguishing character for *H. intertexta* described in the protologue (and annotated by Brown on the syntypes now held in P) is the possession of persistent, undivided carpophores. The carpophores are acrose and distinct in syntypes seen by Richard. The material (not seen by Richard) at BM, K and MEL, also has persistent carpophores but they are filiform and fragile, making them difficult to see with the naked eye, or they readily become detached (missing) from the pedicels due to their fine, fragile structure. Misinterpretation of the fruit morphology on these collections apparently contributed to subsequent misapplications of the published name by George Bentham and Ferdinand von Mueller (Bentham 1867; Mueller 1883).

In his flora treatment of *Hydrocotyle*, Bentham (1867: 340) listed Robert Brown's gatherings of *H. intertexta* under *H. hirta* R.Br. ex A.Rich. This misapplication was due (in part) to the specimens held at BM and K, being a different species to the syntypes held at P, which Richard viewed to formulate the protologue of *H. intertexta*. The application of the name *H. intertexta* is restricted herein to the Paris syntypes, with the exclusion of the BM, K and MEL specimens. As a result, the later named *H. pilifera* Turcz. (Turczaninow 1849) is reduced to a synonym of *H. intertexta* s. str. The misapplication of this entity by Bentham was also due to his failure to observe the remaining filiform carpophores on the '*H. intertexta* syntype', and he deemed it a 'variety of *H. hirta*'. *Hydrocotyle hirta* is readily distinguished from *H. perplexa*, in being villously hairy on stems, leaves and peduncles (all glabrous in *H. perplexa*), its lack of persistent carpophores and in being perennial.

Later in the same treatment, Bentham (1867: 343) recognises *H. hispidula* var. *tenella* Benth. from a gathering originating from the Warren River and provided by F. von Mueller (K 000686147). Its schizocarps share the 'granular-tuberculate' mericarp surfaces of *H. hispidula* but Bentham describes this specimen as more slender and diffuse, with less lobed leaves and shorter petioles, providing justification for assigning this voucher to varietal rank. Following the publication of Bentham's treatment, herbarium specimens with papillate fruit and slender glabrous stems were curated under *H. hispidula* var. *tenella*, including a 'syntype of *H. intertexta*' (collected by Brown) that was incorporated into the collections of the National Herbarium of Victoria (MEL 7978) by Mueller. It was not until 1961 that Hansjörg Eichler recognised that the MEL type of *H. hispidula* var. *tenella* was the same entity as the '*H. intertexta* syntypes' held at K and BM, based on his annotated determinations on K 000686147 and K 000686148. Later in 1962, Eichler also realised that the syntypes of *H. intertexta* held at P, were a different taxon (assignable to *H. pilifera*) and subsequently proposed the manuscript name *H. puberula* ms (later known as *H. sp. Puberula* (H.Eichler 22058)) for the MEL entity.

In my recent molecular phylogenetic study (Perkins 2019a), it was shown that sampled specimens of *H. sp. Puberula* (H. Eichler 22058) and '*H. scutellifera*' were conspecific and that the schizocarp surfaces were polymorphic, either glabrous or papillate. However, the latter name was misapplied, as a re-examination of the syntypes of *H. scutellifera* in the current study revealed them to represent a glabrous, scutellate fruit morph of the later-named *H. blepharocarpa*, which typically has orbicular, scutellate schizocarps, fringed with bristly trichomes. As a result, *H. scutellifera* is re-circumscribed herein, with *H. blepharocarpa* newly placed into synonymy. The new species *H. perplexa* is provided to accommodate specimens previously assignable to *H. sp. Puberula*, plus the specimens with glabrous, elliptic schizocarps that were previously misidentified as *H. scutellifera* (sensu Perkins 2019a). Figure 1 shows a modified version of the figure presented by Perkins (2019a: 135), updated to show the names now accepted for the five species described herein and with their synonyms added.

### Taxonomic descriptions

**Hydrocotyle glochidiata** Benth., *Fl. Austral.* 3: 346 (1867). *Centella glochidiata* (Benth.) Drude, *Nat. Pflanzenfam.* [Engler & Prantl] 3(8): 120 (1897). *Neosciadium glochidiatum* (Benth.) Domin, *Beih. Bot. Centralbl.* 23: 291–292 (1908). *Type*: [Swan River] Western Australia, [1844], *J. Drummond* 4th coll. n. 247 (*lecto*: K 000686118 image!, *fide* A.J. Perkins, *Mol. Phylogen. Evol.* 134: 139 (2019); *isolecto*: G 00367075 image!, G 00367069 image!, LE 00015624 image!); [Swan River] Western Australia, *s. dat.*, *J. Drummond* n. 104, 105 (*syn*: K 000686117 [n. 104] image!, K 000686116 [n. 105] image!).

*Annual herbs* 2–9 cm high, 1–18 cm wide, with 2–6 basal leaves and branched stems bearing leaves and spicate inflorescences. *Stems* erect to ascending, pale green to yellowish green, terete, glabrous. *Stipules* white to pale cream, reniform to broadly ovate, 1.0–3.0 mm long, 0.5–2.5 mm wide, membranous,

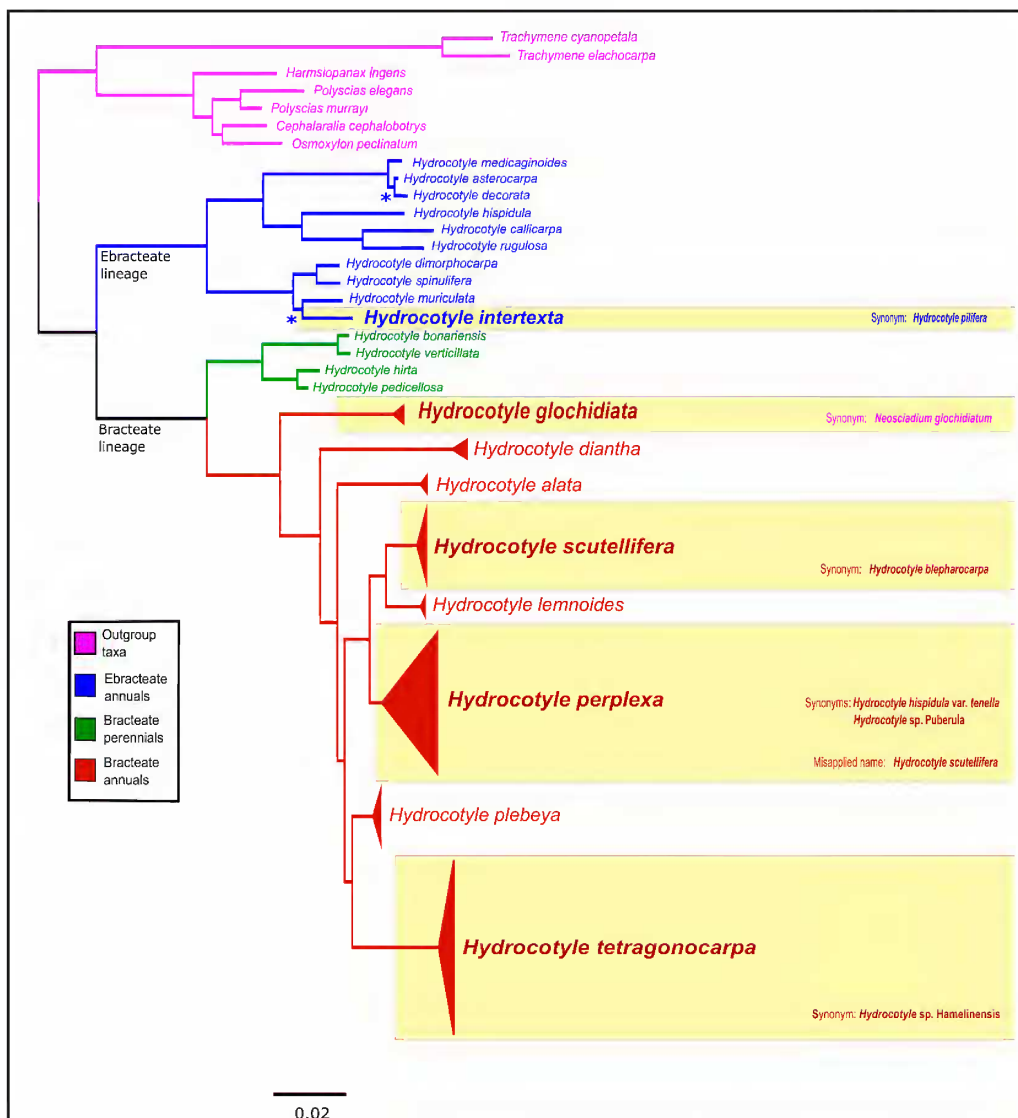


Figure 1. Phylogenetic reconstruction of *Hydrocotyle* and its closely related genera within the Araliaceae based on the nuclear marker ETS, chloroplast markers *psbA-trnH* and *trnL-trnF*, and the coded indels. The Bayesian majority-rule consensus tree is shown with posterior probabilities values < 0.95 indicated with an asterisk (\*) next to the branches. Taxa dealt with in this paper are shown in bold font and highlighted in pale yellow. Synonyms and misapplied names are shown to the right of the highlighted taxa. Phylogram adapted from Perkins (2019a: Figure 2).

translucent, entire to undulate along margins. *Petioles* 2–20 mm long, glabrous. *Leaf blades* simple, dorsiventral, concolorous, carnose, oblanceolate to cuneate, 1.5–15.0 mm long, 1.5–10.0 mm wide, glabrous. *Leaf margins* toothed; teeth 3–7, rounded to obtuse. *Inflorescences* leaf-opposed, spicate, 10–30-flowered. *Peduncles* terete, shorter than subtending leaf, 2–14 mm long, glabrous. *Rachis* 1.5–7.0 mm long, subglabrous with scattered wiry hairs. *Floral bracts* spatulate, spreading with upcurved apices, persistent, 0.3–0.8 mm long. *Pedicels* 0.1–0.2 mm long. *Flowers* all bisexual, protandrous, densely arranged along the rachis appearing sessile. *Sepals* absent. *Petals* 5, white, ovate, induplicate 0.5–0.8 mm long, 0.4–0.6 mm wide; midvein sulcate on abaxial surface. *Filaments* pale



cream, c. 0.3 mm long. *Anthers* creamy yellow or pale crimson, elliptic, c. 0.2 mm long. *Ovaries* pale green at anthesis, bilaterally flattened, elliptic. *Schizocarps* elliptic, symmetrical, becoming inflated, transversely elliptic, hispid with glochidiate hairs arranged in longitudinal rows; mericarps pale green turning pale orange to dark reddish brown at maturity; commissure 95–100% the length of mericarps. *Mericarps* 1.0–1.2 mm long, 0.5–0.6 mm wide, inflated and with a cavity at maturity when mericarps disarticulate; dorsal rib raised, acute; lateral ribs raised, acute, strongly incurved towards median ribs, lined with a row of glochidiate hairs; median ribs not raised; mericarp surface between dorsal and lateral ribs initially convex then becoming concave at maturity, with 2 longitudinal rows of glochidiate hairs; surface between lateral and median ribs concave, with a longitudinal row of glochidiate hairs adjacent to median ribs. *Carpophores* not persistent. *Fruiting styles* c. 0.2 mm long, erect to incurved. *Cotyledons* elliptic to oblanceolate in the seedlings. (Figure 2)

*Diagnostic features.* *Hydrocotyle glochidiata* can be distinguished from all other species of *Hydrocotyle* by a combination of the following characters: succulent annual herbs with glabrous stems and leaves; leaf blades concolorous, oblanceolate to cuneate; flowers with white petals, arranged in dense spicate inflorescences subtended by spatulate floral bracts (Figure 2E); mature schizocarps elliptic, symmetrical, becoming inflated, transversely elliptic, hispid with glochidiate hairs arranged in longitudinal rows (Figure 2C,D); carpophores not persistent.

*Selected specimens examined.* WESTERN AUSTRALIA: edge of salt lake 5.3 km ESE of Morawa on Jones Lake Rd, 20 Sep. 2008, *R.L. Barrett, M.D. Barrett & C. Karsten* RLB 5125 (PERTH); north eastern edge of Lindsay Gordon Lagoon, Lorna Glen Station, 30 July 2006, *G. Byrne* 2266 (PERTH); Lake Annean, 45 km S of Meekatharra, 12 Sep. 1986, *R.J. Chinnock* 7120 (CANB, PERTH); salt lake SW of Winchester, 30 Sep. 1982, *J. Coleby-Williams* 120 (PERTH); south-east end of Hutt Lagoon, 30 Aug. 1983, *R.J. Cranfield* 4010 (PERTH); 4 km S of Coorow, 11 Sep. 1985, *Hj. Eichler* 23679 (CANB, PERTH); airstrip flat on Dirk Hartog Island, 3 Sep. 1972, *A.S. George* 11436 (CANB, PERTH); c. 3 km SSW of Mount Narryer Homestead, 27 Aug. 1996, *A.S. George* 17281 (PERTH); salt lake on E side of Midland Rd, Marchagee Nature Reserve, 3 Oct. 2000, *N. Gibson* 4424 (PERTH); E of Lake Moore and c. 60 km S of Paynes Find and 15 km N of Mouroubra homestead, 7 Oct. 1991, *W. Greuter* 22613 (PERTH); Little Lagoon 2 km E of Denham, 28 Aug. 1989, *G.J. Keighery* 10557 (PERTH); Birrida Tamala Station 4.8 km S of homestead, 20 Aug. 1995, *G.J. Keighery & N. Gibson* 953 (PERTH); Lindsay Gordon Lagoon, 5 Sep. 2003, *K.F. Kenneally & D.J. Edinger* K12531 E3730 (PERTH); Weelarrana Station, 80 km SSE of Newman, 16 km SW of Weelarrana Station homestead, 5.5 km SW of Weelarrana Hill, at central northern edge of the lake, 30 Aug. 2016, *M.N. Lyons & R.A. Coppen* FV0724 (PERTH); 4.5 km SSE of Boorabbin, 27 Aug. 1981, *K.R. Newbey* 8695 (PERTH); southern end of Lake Macleod, 6.9 km along Blowholes Rd from the North West Coastal Hwy, 18 Sep. 2005, *A.J. Perkins s.n.* (NSW, PERTH, SYD); salt lake in Marchagee Nature Reserve 9 km S of Coorow, 15 Sep. 2005, *A.J. Perkins s.n.* (NSW, PERTH, SYD); Muggon Station 8.2 km W of homestead, 4 Sep. 1999, *S. Patrick et al.* 3128 (PERTH); 30.5 km W of Jaurdi Station Homestead access track off the Trans-Australian Rail line, 11 Oct. 1999, *L.W. Sage & F. Hort* 2162 (PERTH); Hamersley Lakes 16 km S of Mt Jackson Homestead, 7 Oct. 1983, *P.S. Short* 1994 (CANB, MEL, PERTH); 7.2 km from Bunjil along main road to Latham, 23 Oct. 1983, *P.S. Short* 2185 (CANB, MEL).

*Phenology.* This species is a winter annual, with flowering and fruiting occurring from August to October.

*Distribution and habitat.* *Hydrocotyle glochidiata* is widely distributed in Western Australia, from the Moora region in the south-west, Boorabbin in the south-east, Weelarrana Station in the north-east and the Carnarvon region in the north-west (Figure 3). This annual species grows in damp sandy soils associated with salt pans and shorelines of saline lakes (Figure 2F).

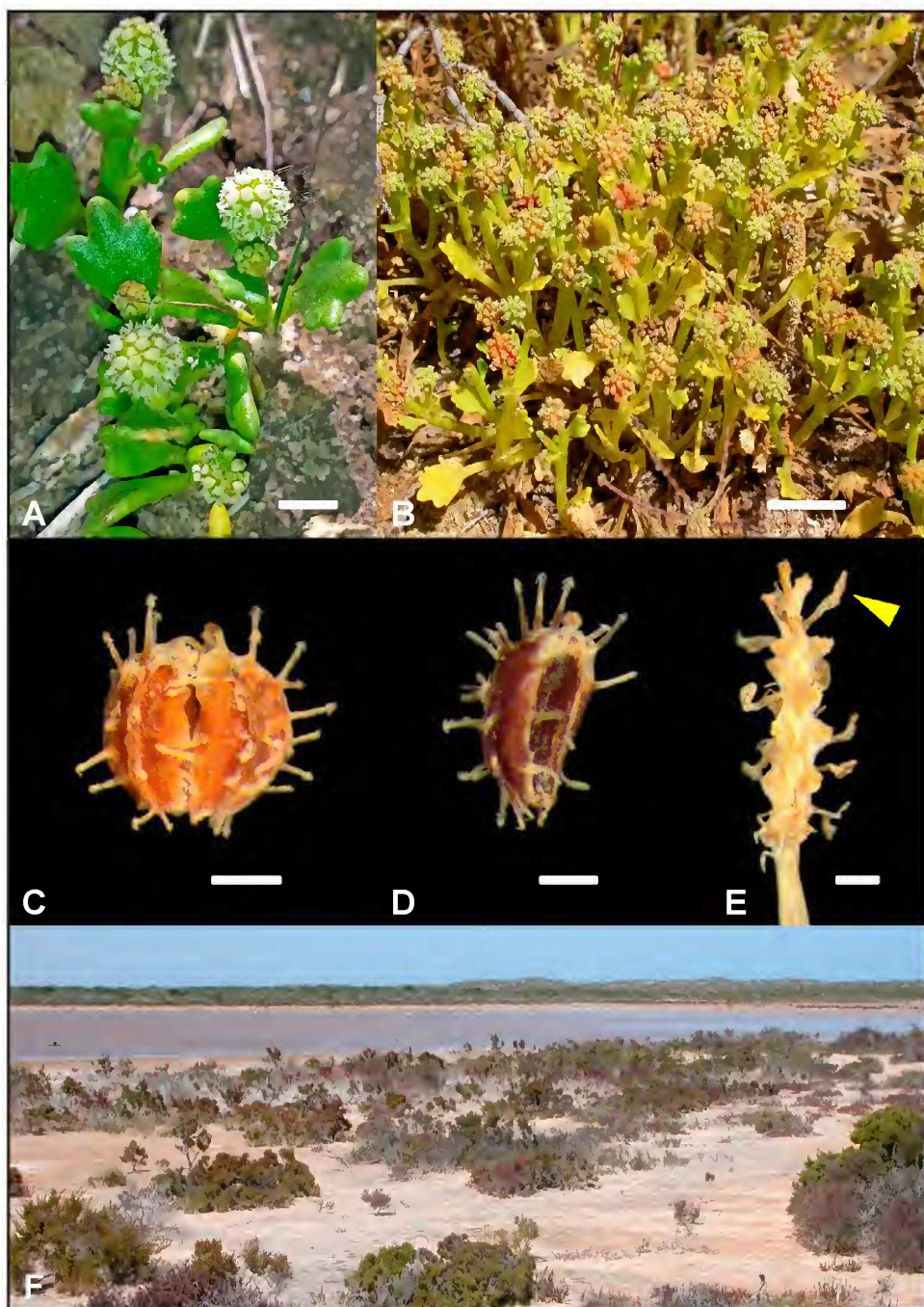


Figure 2. *Hydrocotyle glochidiata*. A – fertile plants *in situ* during early stages of anthesis; B – fertile plants *in situ* during later stages of fruit maturation; C – lateral view of a mature schizocarp prior to disarticulation of the two mericarps; D – lateral view of a single mericarp bearing glochidiate trichomes and showing internal cavity; E – peduncle and rachis of an inflorescence after full disarticulation of mericarps, showing persistent floral bracts (yellow arrowhead), reduced pedicels and a few scattered hairs along the rachis; F – typical habitat. Scale bars = 5 mm (A); 20 mm (B); 0.5 mm (C, D); 1 mm (E). Vouchers: PERTH 08029504 (A); PERTH 08029466 (B); PERTH 08728712 (C, D, E). Photographs by A. Perkins.

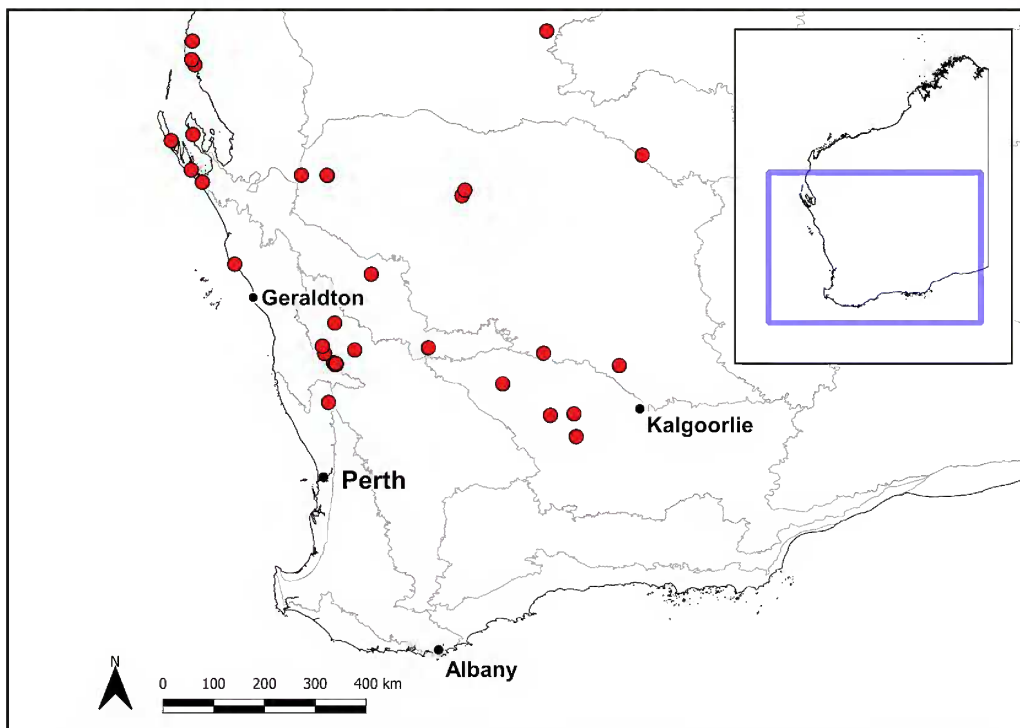


Figure 3. Distribution of *Hydrocotyle glochidiata* (●) based on selected specimens held at CANB, MEL, NSW and PERTH. Map with *Interim Biogeographic Regionalisation for Australia* version 7 bioregions (Department of the Environment 2013) shown in grey. Based on specimen data from Western Australian Herbarium (1998–) and AVH (2019).

**Conservation status.** *Hydrocotyle glochidiata* is a widely distributed species, specifically associated with saline habitats. No conservation code applies.

**Etymology.** The epithet is derived from the Latin *glochidiatus*, ‘provided with barbs’, in reference to the distinctive glochidiate hairs on the schizocarps (Figure 2C,D). The common name ‘Salt-lake Pennywort’ is here suggested.

**Affinities.** *Hydrocotyle glochidiata* is a morphologically distinct species that Domin (1908) placed in the monotypic genus *Neosciadium* Domin due to its succulent leaves and stems, leaf blades with tapering bases, flowers in dense spicate inflorescences, distinctive glochidiate trichomes on schizocarps, and mericarps that are slightly laterally flattened and broadly trapezoidal in cross-section. Many of the key morphological features that Domin considered to be diagnostic, such as succulence and simple, toothed leaves with tapering bases, are merely autapomorphies associated with the saline habitat of this distinctive species. Recent molecular phylogenetic analyses (Perkins 2019a) place this species within a clade of annual *Hydrocotyle* that have persistent floral bracts, referred to as the bracteate annuals (Figure 1).

***Hydrocotyle intertexta*** R.Br. ex A.Rich. *Ann. Gen. Sci. Phys.* 4: 213. t. 61. fig. 28 (1820). *Type citation*: ‘Elle a été rapportée de la Nouvelle-Hollande par M. R. Brown. (V.S.)’. *Type specimens*: King George III Sound [Albany, Western Australia], December 1801, *R. Brown s.n.* (*lecto*, here designated: P 00115415 image!; *isolecto*: P 00115414 image!); King George III Sound [Albany, Western Australia], December 1801, *R. Brown s.n.* (excluded *syn*: BM 000810385 image!, K 000686148 image!, K 000686149 image!, MEL 7978!).



*Hydrocotyle pilifera* Turcz. *Bull. Soc. Imp. Naturalistes Moscou* 22/2 (3): 26–27 (1849). *Type citation*: ‘Nova Hollandia, Swan River, Drum. coll. 1839. Numerus mihi ignotus’. *Type specimens*: Swan River, Western Australia, 1839, *J. Drummond s.n.* (*lecto*, here designated: KW 001001400 image!; *isolecto*: K 000686153 image! [bottom row of plants on sheet]).

*Hydrocotyle pilifera* var. *glabrata* Benth. *Fl. Austral.* 3: 344 (1867). *Type citation*: ‘Swan River, Drummond 1st. Coll.’. *Type specimen*: Swan River, Western Australia, *J. Drummond* (*holo*: K 000686154 image!).

[*Hydrocotyle hirta* auct. non R.Br. ex A.Rich.: G. Bentham in *Fl. Austral.* 3: 340 (1867) *pro parte*.]

*Annual herbs* 1.5–15 cm high, 2–25 cm wide, with 2–6 basal leaves and branched stems bearing leaves and umbellate inflorescences. *Stems* ascending to erect, pale green to reddish green, terete, glabrous or sparsely to villously covered with wiry simple hairs. *Stipules* white, ovate, 1.0–4.5 mm long, 0.8–4.0 mm wide, membranous, translucent, irregularly toothed to fimbriate along margins. *Petioles* 4–60 mm long, glabrous or sparsely to densely hairy. *Leaf blades* simple, dorsiventral, carnose, trilobed to palmatifid in juvenile leaves, palmatifid to pedate in mature leaves, 4–25 mm long, 6–30 mm wide; adaxial surface light green or reddish green, glabrous; abaxial surface slightly paler in colour than adaxial, glabrous or sparsely covered with simple hairs. *Leaf margins* toothed; teeth mostly rounded to obtuse or occasionally acute. *Median leaf lobes* ovate to oblanceolate, 3–20 mm long, 2–12 mm wide, with 3–7 marginal teeth. *Lateral leaf lobes* 3–15 mm long, 3–20 mm wide, with 4–9 marginal teeth; leaf sinuses 20–75% of lateral leaflet length. *Inflorescences* leaf-opposed, simple umbels, anthesis centripetal, 3–16(–20)-flowered, 2–6 mm wide. *Peduncles* terete, much shorter than subtending leaf at anthesis, becoming up to half as long as the subtending leaf when in fruit, 0.2–4.5 mm long, glabrous or sparsely to villously covered with simple hairs. *Floral bracts* absent. *Pedicels* light green, subterete at anthesis, 0.1–0.2 mm long. *Flowers* all bisexual, protandrous. *Sepals* absent. *Petals* 5, white to pale cream, ovate, 0.5–0.7 mm long, 0.4–0.5 mm wide. *Filaments* pale cream, 0.4 mm long. *Anthers* creamy yellow, elliptic, 0.2 mm long. *Ovaries* pale green at anthesis, bilaterally flattened, broadly obcordate, dorsal and lateral ribs raised in profile. *Fruiting pedicels* distinctly flattened longitudinally, 1.0–2.5 mm long, outermost pedicels basally connate, each joined by a membranous flap of tissue. *Schizocarps* bilaterally flattened, symmetrical, broadly obcordate; mericarps light green turning dark reddish brown at maturity; commissure 95% the length of mericarps. *Mericarps* 0.8–1.2 mm wide, 1.3–1.6 mm long, minutely colliculate; dorsal rib conspicuous, thickened; lateral ribs prominently thickened and raised; mericarp surface between dorsal and lateral ribs concave, with (4–)5–7(–8) prominent tubercles longitudinally arranged along the margins of both ribs, often with interconnecting transverse ridges; surface between lateral and median ribs deeply concave, glabrous or occasionally with a few obscure tubercles adjacent to lateral rib. *Carpophores* persistent, acerose, 0.7–1.0 mm long. *Fruiting styles* slender at the base, 0.5 mm long, fully reflexed. *Cotyledons* oblong to oblanceolate in the seedlings. (Figure 4)

*Diagnostic features.* *Hydrocotyle intertexta* can be distinguished from all other species of *Hydrocotyle* by a combination of the following characters: annual herbs with ebracteate flowers densely arranged in simple, dome-shaped umbels; pedicels subterete, becoming distinctly flattened when in fruit, outermost pedicels basally connate (joined by a membranous flap of tissue); mericarp surface between median and lateral ribs distinctly concave and glabrous; mericarp surface between dorsal and lateral ribs with prominent tubercles longitudinally arranged along the margins of both ribs (Figure 4C, D), often with interconnecting transverse ridges; carpophores persistent, acerose (Figure 4D).

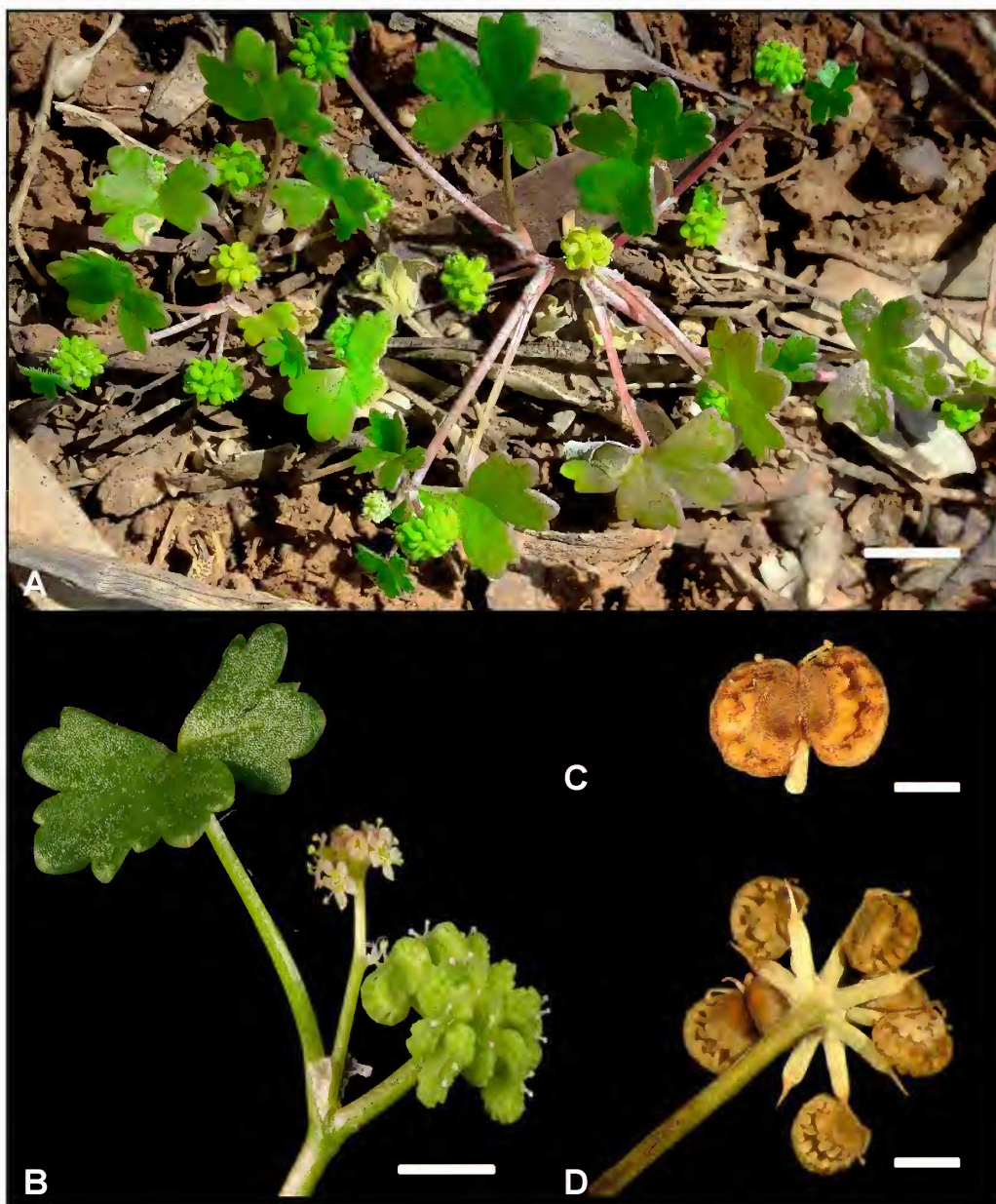


Figure 4. *Hydrocotyle intertexta*. A – fertile plant *in situ* flowering and fruiting; B – portion of flowering plant showing an umbel at the early stages of anthesis and a developing infructescence; C – lateral view of a mature schizocarp; D – abaxial view of a mature infructescence showing mature schizocarps, longitudinally flattened fruiting pedicels and persistent acerose carpophores. Scale bars = 5 mm (B); 1 mm (C); 2 mm (D). Vouchers: *K.R. Thiele* 3394 (B); *M. Hislop* 1602 (C, D). Photographs by A. Perkins (A, C, D) and K. Thiele (B).

*Selected specimens.* WESTERN AUSTRALIA: 5 km NE of Norseman Post Office, c. 1 km N of Eyre Hwy, 29 Aug. 1974, *A.C. Beauglehole* 49342 (CANB, MEL, PERTH); 4.5 km SW of Illaara no. 2, Illaara Station, 12 Sep. 1988, *R.J. Cranfield* 7393 (CANB, PERTH); c. 2.5 km WNW of Bolgart on Bolgart West Rd, 26 Sep. 2000, *R. Davis* WW09-10 (PERTH); Hamelin Bay, 2 Oct. 1976, *Hj. Eichler* 22031 (CANB, NSW, PERTH); Totadgin Rock, c. 13 km SSW of Merredin, 15 Sep. 1982, *Hj. Eichler*



23010 (CANB, NSW, PERTH); Tutanning Reserve, SE of Pingelly, 21 Sep. 1974, *A.S. George* 12863 (CANB, PERTH); c. 8 km NE of Bungalbin Hill, Aurora Range, 25 Sep. 1995, *N. Gibson & M. Lyons* 3350 (PERTH); Dalwallinu Town Reserve towards NE corner, 16 Sep. 1999, *M. Hislop* 1602 (PERTH); 13 km ENE of Gunyidi, 2.1 km E of intersection of Noble Rd on Gunyidi Wubin Rd, S of road on E side of lake, 28 Sep. 1999, *M.N. Lyons & S.D. Lyons* 4444 (PERTH); Weld Range, on Madoonga Station, c. 60 km NNW of Cue, c. 9 km E of The Gap and 1 km E of Little Wilgie Mia, 2 Sep. 2005, *A. Markey & S. Dillon* 3201 (PERTH); Mount Willgonarinya, c. 72 km SSW of Balladonia Motel, Eyre Hwy, 15 Sep. 1980, *K.R. Newbey* 7394 (PERTH); Pallarup Rocks, 70 m W of outcrops, Pallarup Nature Reserve, 27 Sep. 2005, *A.J. Perkins s.n.* (NSW, PERTH); roadside along Mullewa Wubin Rd, c. 150 m N of Wubin, 4 Oct. 2007, *A.J. Perkins s.n.* (NSW, PERTH); north side of Warriedar Copper Mine Rd, along embankment of a dry creek, 4 Oct. 2007, *A.J. Perkins s.n.* (NSW, PERTH); dirt track running N of Hamelin Bay, 300 m E of Hamelin Bay carpark, 19 Oct. 2007, *A.J. Perkins s.n.* (NSW, PERTH); 80 m N of the carpark entrance to Wedge Lookout, along Indian Ocean Drive, 9 Oct. 2016, *A.J. Perkins* AJP-WA117 (PERTH); c. 2 km E of Bremer Bay town centre and bayside to the entrance to Devil Creek, 24 Oct. 2018, *A.J. Perkins* AJP-WA151 (PERTH); Mortlock Nature Reserve, 28 Sep. 2007, *K.R. Thiele* 3394 (PERTH); junction of Douglas Rd and Maders Rd, NW of Woodanilling, 16 Oct. 2012, *WA Herbarium* WAH229 (PERTH); 13 km W of Gnowangerup, 27 Sep. 1966, *P.G. Wilson* 4164 (CANB, PERTH).

SOUTH AUSTRALIA: Hambidge Flora Reserve, c. 3 km E of Prominent Hill, 8 Oct. 1966, *C.R. Alcock* 1129 (CANB); Hundred of Ramsay, c. 15 km ESE of Minlaton, c. 90 km W of Adelaide, 23 Aug. 1970, *B.J. Blaylock* 1521 (CANB); Gawler Ranges, c. 11 km W of Kolendo, c. 20 km WNW of Nonning, c. 120 km W of Port Augusta, 26 Sep. 1969, *J. Carrick* 2347 (CANB); c. 15 km W of Murray Bridge, Scrub SE of 'Mallee View' Homestead, 30 Sep. 1974, *J. Carrick* 3657 (CANB); Gawler Ranges, Granite Hills 5 km S of Scrubby Peak, 19 Oct. 1975, *R.J. Chinnock* 2885 (CANB); c. 20 km NW of Port Kenny, in scrubland E of the road to Streaky Bay, 13 Oct. 1967, *Hj. Eichler* 19473 (CANB); Gawler Range, c. 32 km NNE of Minnipa, hill NW of the track to Yardea, 27 Oct. 1968, *Hj. Eichler* 20479 (CANB); Gawler Ranges, Yandinga Gorge, on hill SW of well in the valley, 13 Oct. 1969, *Hj. Eichler* 20650 (CANB); Gawler Ranges, between Minnipa and Yardea, c. 4.5 km NE of Peterby Yards, 17 Sep. 1971, *Hj. Eichler* 21378 (CANB); Lowan Conservation Park, 10 Oct. 1984, *E.N.S. Jackson* 5553 (CANB); roadside c. 6 km NW of Stansbury, just S of the Minlaton-Stansbury Rd, 11 Oct. 1970, *A.E. Orchard* 2585 (CANB); Hambidge Reserve, Eyre Peninsula, NW and NNW from Prominent Hill, 8 Oct. 1966, *D.E. Symon* 4175 (CANB); Moonta Rd, Yorke Peninsula, *s. dat.*, *J.G.O. Tepper* 112 (MEL); crown land adjacent to Pinkawillinie Recreation Park, c. 50 km W of Kimba, c. 7 km NE of Corrobinnie Hill, 5 Oct. 1981, *J.Z. Weber* 6899 (CANB).

VICTORIA: Berrook Track, 17.9 km W of Sunset Tank, 14 Oct. 1986, *G.R. Lucas & D.M. Parks s.n.* (MEL 1554657); 10 miles S of Murrayville, 1 Oct. 1968, *I. Noy-Meir* 1387 (CANB).

*Phenology.* This species is a winter annual, with flowering and fruiting occurring from August to December.

*Distribution and habitat.* *Hydrocotyle intertexta* is broadly distributed across the south-west of Western Australia and the south-eastern regions of South Australia, also extending eastward over the state border into north-western Victoria (Figure 5). This species grows mostly in sand or sandy loam soils in a variety of different vegetation types, from coastal heathlands and woodlands, to inland *Eucalyptus* and *Melaleuca* dominant woodlands, as well as arid mallee communities.

*Conservation status.* *Hydrocotyle intertexta* is a widely distributed and common species. No conservation code applies.

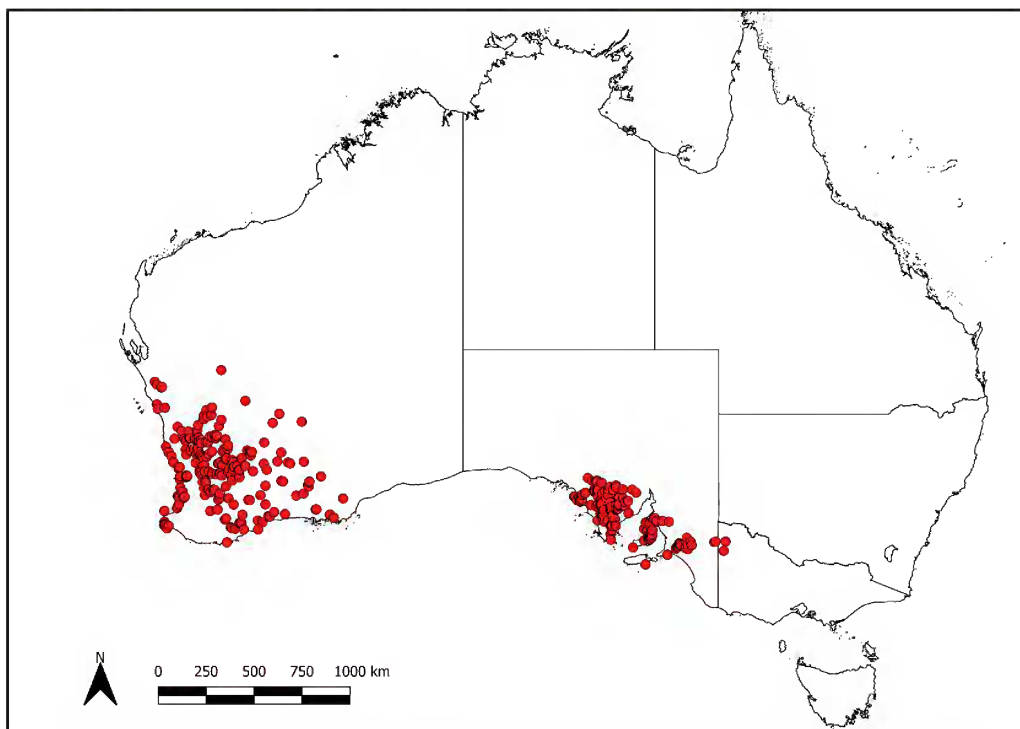


Figure 5. Distribution of *Hydrocotyle intertexta* (●) based on selected specimens held at CANB, MEL, NSW and PERTH. Map of Australia with state borders. Based on specimen data from Western Australian Herbarium (1998–) and AVH (2019).

*Etymology.* The epithet is derived from the Latin *intertextus*, meaning ‘interwoven’, probably in reference to the prominent tubercles on the fruit which are longitudinally arranged along the margins of the lateral and dorsal ribs of the mericarps, often with interconnecting transverse ridges, making them appear interwoven (Figure 4C).

*Affinities.* *Hydrocotyle intertexta* is an ebracteate annual with fruiting pedicels that are distinctly flattened and joined at their base by a membranous flap of tissue, and with persistent, acerose carpophores. These morphological character traits are shared by *H. corynophora* F.Muell., *H. dimorphocarpa* A.J.Perkins, *H. muriculata* Turcz. and *H. spinulifera* (Perkins 2017a, 2018a). The relationship of *H. intertexta* with *H. dimorphocarpa*, *H. muriculata* and *H. spinulifera*, is highly supported based on phylogenetic analyses of chloroplast and nuclear DNA sequence data (Figure 1; Perkins 2019a). *Hydrocotyle intertexta* can readily be distinguished from these closely related taxa by the prominent tubercles that are longitudinally arranged along the margins of the lateral and dorsal ribs of the mericarps, often with interconnecting transverse ridges (Figure 4C).

*Typification.* The two sheets held in Paris (P00115414 and P00115415) are the original material viewed (in the dried state) by Achille Richard when he formulated the species description for the protologue of *H. intertexta* in 1820. They also contain annotated descriptive notes in Robert Brown’s hand that correspond to the protologue. The specimen P00115415 is the better quality of the two syntypes at Paris, with persistent carpophores clearly visible and is, therefore, designated as lectotype. Three remaining possible syntypes lodged at BM, K and MEL, bear whole plants that are more than twice the size of those mounted on the P sheets, and represent a second, distinct taxonomic entity (corresponding to *H. perplexa*). Bentham (1867) viewed the BM specimen and concluded that *H. intertexta* was just a

variety of *H. hirta* as it lacked carpophores, which is a diagnostic character cited in the protologue (Richard 1820). Examination of images of the BM, K and MEL material indicated that these specimens do possess carpophores (Wakefield 1951; this study), but they are filiform and fragile, often prone to breaking off in the process of pressing, drying and mounting of the specimens. Bentham's misapplication of the BM specimen to *H. hirta* was understandable since he was unaware that the syntypes Richard viewed (held at P) were part of a mixed gathering made by Brown.

Consequently, in 1845 Turczaninow described *H. pilifera* based on collections of this taxon made by Drummond in 1839. The herbarium voucher KW 001001400 is selected as an appropriate lectotype for *H. pilifera* as it matches the taxonomic description and conforms to the published protologue (Turczaninow 1849).

### **Hydrocotyle perplexa** A.J.Perkins, *sp. nov.*

*Type*: south side of Mandalay Beach Road, 2.2 km from South Western Highway, Western Australia, 30 October 2018, A.J. Perkins AJP-WA 159 (*holo*: PERTH 09078185; *iso*: AD, BRI, MEL).

*Hydrocotyle hispidula* var. *tenella* Benth., *Fl. Austral.* 3: 343 (1867). *Type citation*: 'Warren river, Herb. F. Mueller'. *Type specimens*: 'Warren River' [Western Australia], *s. dat.*, F. von Mueller *s.n.* (*lecto*, here designated: K 000686147 image!; *isolecto*: MEL 8275!).

[*Hydrocotyle hirta* auct. non R.Br. ex A.Rich.: G. Bentham in *Fl. Austral.* 3: 339–340 (1867), *pro parte*.]

[*Hydrocotyle scutellifera* auct. non Benth.: A.J. Perkins in *Mol. Phylogen. Evol.* 134: 129–141 (2019).]

*Hydrocotyle puberula* H.Eichler ms, Western Australian Herbarium, in *FloraBase*, <https://florabase.dpaw.wa.gov.au/> [accessed 1 April 2019].

*Hydrocotyle* sp. *Puberula* (H.Eichler 22058), *Australian Plant Census*, <https://id.biodiversity.org.au/name/apni/241655> [accessed 1 April 2019].

*Annual herbs* 1–5 cm high, 10–80 cm wide, with 2–8 basal leaves and branched stems bearing leaves and umbellate inflorescences. *Stems* prostrate to decumbent, pale green to yellowish green or reddish green, terete, glabrous, occasionally producing roots at nodes. *Stipules* white, elliptic to broadly ovate, 0.8–3.0 mm long, 0.8–3.0 mm wide, membranous, translucent, irregularly toothed to fimbriate along margins. *Petioles* 2–50 mm long, glabrous. *Leaf blades* predominantly simple rarely compound, dorsiventral, carnose, mostly trilobed to palmatifid, rarely trifoliolate in mature leaves, 4–16 mm long, 4–20 mm wide, cordate at the base, glabrous; adaxial surface light green; abaxial surface slightly paler in colour than adaxial. *Leaf margins* toothed; teeth mostly rounded to obtuse or occasionally acute. Median leaf lobes oblanceolate, 3–12 mm long, 2–11 mm wide, with 3–5 marginal teeth. Lateral leaf lobes 2–11 mm long, 3–14 mm wide, with 2–8 marginal teeth; leaf sinuses 15–50% of lateral leaflet length. *Inflorescences* leaf-opposed, simple umbels, anthesis centripetal, 6–20-flowered, 2–4 mm wide. *Peduncles* terete, shorter than subtending leaf at anthesis, becoming distinctly longer than subtending leaf when in fruit, 3–35 mm long, glabrous. *Floral bracts* lanceolate, 0.4–1.0 mm long, margins entire to occasionally toothed. *Pedicels* light green, subterete, longitudinally flattened, 0.1–0.3 mm long. *Flowers* all bisexual, protandrous. *Sepals* absent. *Petals* 5, white to pale cream, ovate, 0.4–0.5 mm long, 0.3–0.4 mm wide. *Filaments* white, *c.* 0.3 mm long. *Anthers* creamy yellow to crimson, elliptic, *c.* 0.2 mm long. *Ovaries* pale green at anthesis, bilaterally flattened, elliptic. *Fruiting pedicels*

0.4–1.0 mm long, longitudinally flattened. *Schizocarps* bilaterally flattened, symmetrical, elliptic; initially light green, often fading to pale cream before turning light brown at maturity; commissure 90–95% the length of mericarps. *Mericarps* reniform, glabrous or papillate, 1.0–1.2 mm long, 0.5–0.6 mm wide; bases cordate, apices subcordate to cordate; dorsal and lateral ribs conspicuous, acute; median ribs inconspicuous; surface between dorsal and lateral ribs flat to slightly concave; surface between lateral and median ribs slightly concave. *Carpophores* persistent but fragile, filiform, 0.4–0.6 mm long. *Fruiting styles* distinctly thicker at the base, c. 0.3 mm long, fully reflexed. *Cotyledons* elliptic to lanceolate in the seedlings. (Figure 6)

*Diagnostic features.* *Hydrocotyle perplexa* can be distinguished from allied species by a combination of the following characters: glabrous annuals herbs, flowers with white to pale cream petals, fruiting peduncles longer than opposing leaves, reniform mericarps with glabrous or papillate surfaces, persistent floral bracts (Figure 6B) of similar length to fruiting pedicels (0.4–1.0 mm long), reflexed fruiting styles, persistent carpophores filiform and fragile (Figure 6C).

*Selected specimens examined.* WESTERN AUSTRALIA: Windy Harbour, 2 Dec. 1986, *A.R. Annels* 1896 (PERTH); Mays Rd, 4.5 km due N of Manjimup, 20 Nov. 1994, *A.R. Annels* 4979 (PERTH); coastal foreshore near Ledge Isle, 13 Dec. 1983, *R.J. Cranfield* 4887 (PERTH); 20 miles S of Gum Nut Rd, Northcliffe, 2 Dec. 1999, *R.J. Cranfield* 14510 (PERTH); Mount Chudalup, at base, 3 Oct. 1976, *Hj. Eichler* 22056 (CANB, PERTH); Mount Chudalup, at base, 3 Oct. 1976, *Hj. Eichler* 22058 (CANB, PERTH); Mount Chudalup, 22 Sep. 1982, *Hj. Eichler* 23049 (CANB, PERTH); 0.7 km from Bussell Hwy on road to Yalgourup beach, 25 Sep. 1985, *Hj. Eichler* 23697 (CANB, PERTH); c. 1 km S of junction of Thomas Rd and Johnson Rd, E of Medina, 18 Sep. 1977, *A.S. George* 14906 (CANB, PERTH); Lake William, West Cape Howe, 30 km W of Albany, 9 Nov. 1987, *G.J. Keighery* 9808 (PERTH); Ellis Rd, Yalgourup National Park, 14 Oct. 1996, *G.J. Keighery* 14555 (PERTH); central firebreak, above N flat, Gingilup Swamps Nature Reserve, 3 Dec. 2002, *G.J. Keighery*, *N. Gibson & W. Muir* 7227 (PERTH); granite outcrop 100 m N of Mount Chudalup peak, D'Entrecasteaux National Park, 16 Oct. 2007, *A.J. Perkins s.n.* (NSW, PERTH); granite outcrop 400 m inside West Cape Howe National Park entrance heading south along Hortons Rd South, 18 Oct. 2007, *A.J. Perkins s.n.* (PERTH, NSW); western shoreline of Lake Preston c. 350 m E of Preston Beach township, 20 Nov. 2016, *A.J. Perkins* AJP-WA 134 (PERTH); Owingup Nature Reserve, Parryville, W side of Boat Harbour Rd 1.6 km from South Coast Hwy, 20 Nov. 2017, *A.J. Perkins* AJP-WA 146 (AD, CANB, MEL, NSW, PERTH); south side of Ficifolia Rd, 240 m W of Peaceful Bay Rd, Walpole-Nornalup National Park, 21 Nov. 2017, *A.J. Perkins* AJP-WA 147 (MEL, NSW, PERTH); 800 m W of Windy Harbour Rd and c. 3.5 km SW of Mount Chudalup, 22 Nov. 2015, *A.J. Perkins & R. Davis* AJP-WA 111 (PERTH); 800 m W of Windy Harbour Rd and c. 3.5 km SW of Mount Chudalup, 22 Nov. 2015, *A.J. Perkins & R. Davis* AJP-WA 112 (PERTH); south-west Porongurup Range, western slopes of Nancy's Peak, 29 Sep. 1966, *P.G. Wilson* 4251 (CANB, PERTH).

*Phenology.* This species is a winter annual, with flowering and fruiting occurring from late August to December.

*Distribution and habitat.* *Hydrocotyle perplexa* is broadly distributed in the south-west of Western Australia, from coastal areas of Perth in the north, to Cape Leeuwin in the south-west, through to the Porongurup Range and Albany in the east (Figure 7). Plants often grow in moist, sheltered positions in sandy humic soil associated with coastal *Agonis* woodlands, or *Melaleuca* woodlands along freshwater swamps, creeks or lakes, or on moist granite outcropping along the coast and in near-coastal areas (Figure 6D).



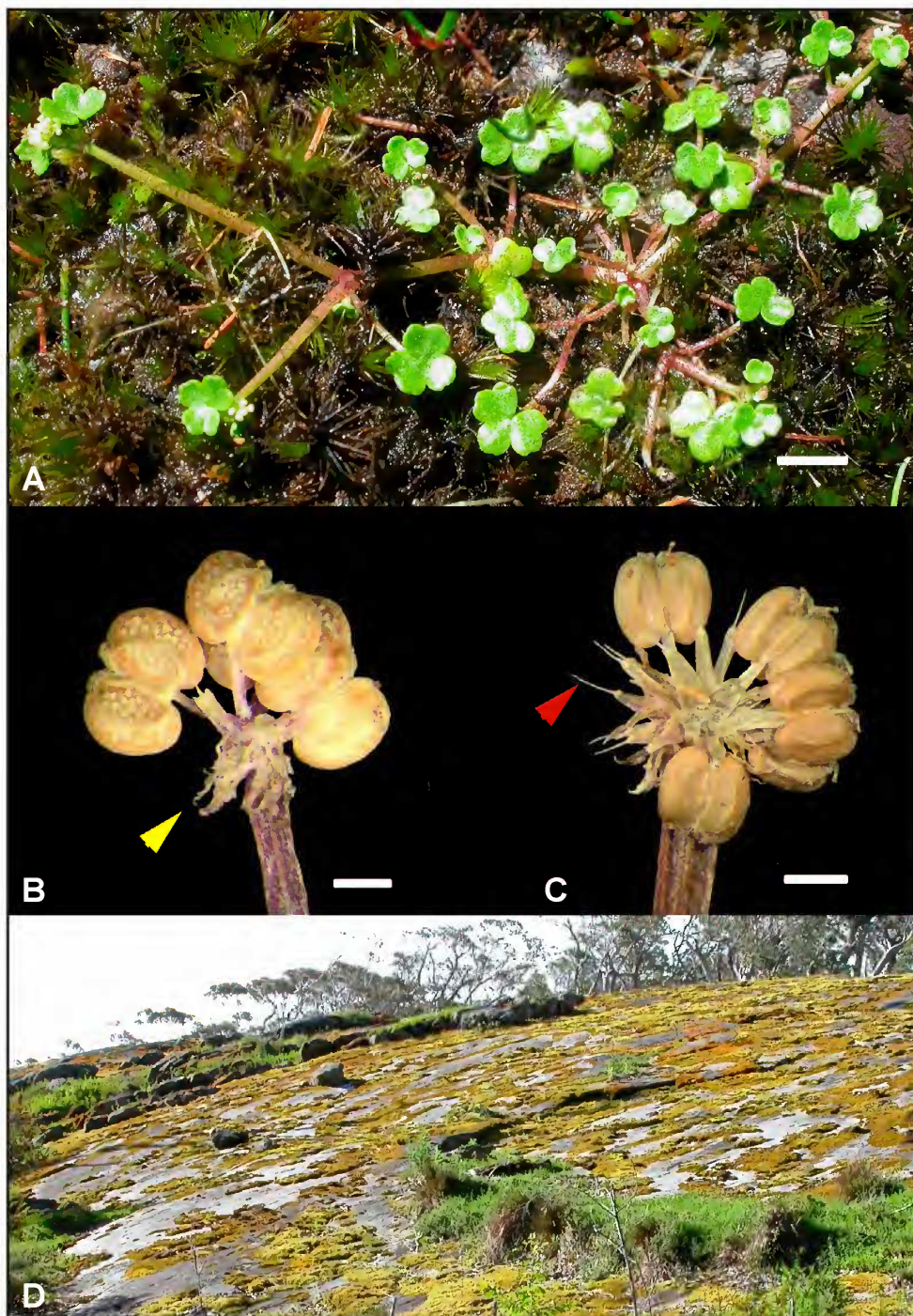


Figure 6. *Hydrocotyle perplexa*. A – fertile plants in situ during early stages of anthesis; B – infructescence showing floral bracts (yellow arrowhead) subtending pedicels and mature schizocarps with papillate surfaces; C – infructescence showing flattened pedicels with persistent filiform carpophores (red arrowhead) and mature schizocarps with glabrous surfaces; D – typical habitat. Scale bars = 10 mm (A); 1 mm (B, C). Vouchers: PERTH 08048622 (A); PERTH 04055950 (B); PERTH 06527744 (C). Photographs by A. Perkins.



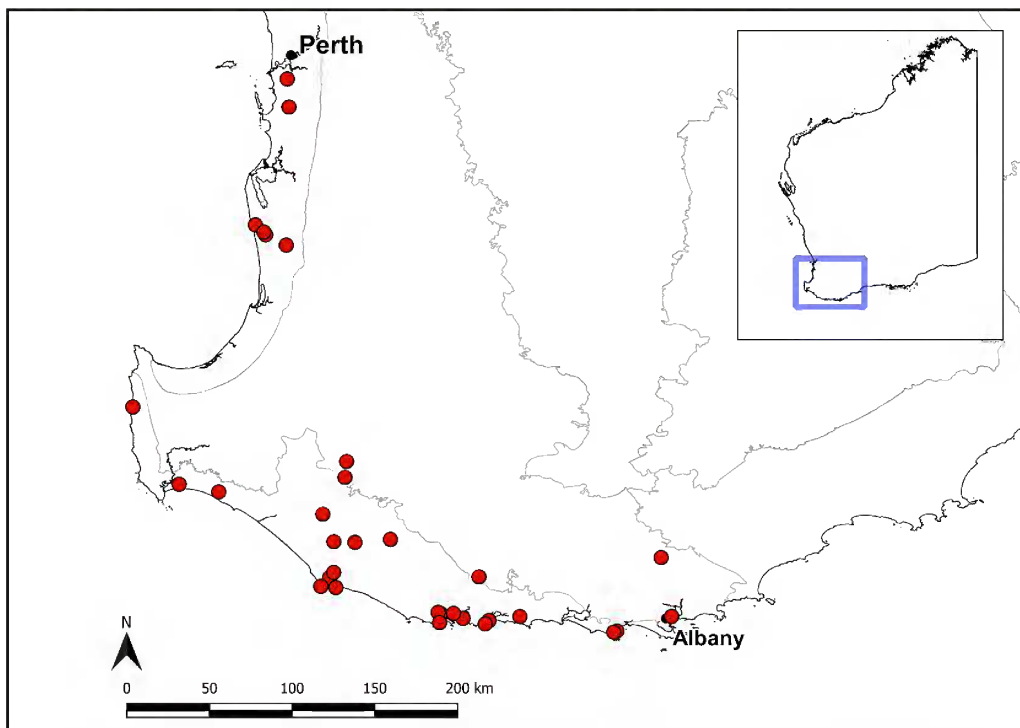


Figure 7. Distribution of *Hydrocotyle perplexa* (●) based on selected specimens held at CANB, MEL, NSW and PERTH. Map with *Interim Biogeographic Regionalisation for Australia* version 7 bioregions (Department of the Environment 2013) shown in grey. Based on specimen data from Western Australian Herbarium (1998–) and AVH (2019).

**Conservation status.** *Hydrocotyle perplexa* is a widely distributed and common species. No conservation code applies.

**Etymology.** The epithet is derived from the Latin *perplexus*, meaning ‘obscure, confused, intricate’. It firstly refers to the complicated and confused taxonomic history of this taxon based on the misapplications of obscure, polymorphic fruit character traits formerly used to circumscribe annual taxa in Western Australia. This epithet refers also to the intricate, entanglement of stems in large individual plants and to plants often found growing in dense colonies. The common name ‘Intricate Pennywort’ is here suggested.

**Affinities.** Recent molecular phylogenetic reconstructions (Perkins 2019a) place *H. perplexa* within a clade of bracteate annuals and in a sister relationship with *H. scutellifera* and *H. lemnoides* (Figure 1). *Hydrocotyle perplexa* is morphologically most similar to *H. scutellifera* s. str. and can be readily distinguished from it by having white to pale cream petals (crimson in *H. scutellifera*), elliptic schizocarps (orbicular in *H. scutellifera*), shallowly concave mericarp surfaces (scutellate mericarp surfaces in *H. scutellifera*), floral bracts similar in length to fruiting pedicels (distinctly shorter for *H. scutellifera*), reflexed fruiting styles (erect to ascending fruiting styles in *H. scutellifera*) and persistent carpophores filiform and fragile (carpophores not persistent in *H. scutellifera*).

**Typification.** The herbarium voucher K 000686147 is selected as an appropriate lectotype of *H. hispidula* var. *tenella* as it is marked as seen by Bentham for his *Flora Australiensis* treatment (1867) and has flowering umbels and mature fruit that conform to his taxonomic description.

*Notes.* As discussed in detail in the first subsection of this taxonomy account, *H. perplexa* is described as a new species as a result of a historic series of misapplied names and the lack of an available epithet for this taxon.

**Hydrocotyle scutellifera** Benth., *Fl. Austral.* 3: 343 (1867). *Type citation:* ‘Swan River, Drummond 1st Coll. and 2nd Coll. n. 4’. *Type specimens:* Swan River, [Western Australia], 1839, *J. Drummond* [1st coll.] *s.n.* (*lecto*, here designated: K 000686144 image!); Swan River, [Western Australia], 1843, *J. Drummond*, 2nd Coll. n. 4. (*syn:* BM 000810391 image!, G 00366924 image!, G 00366946 image!, K 000686143 image! [left hand specimen on the sheet accompanied with illustrations of a stipule and schizocarp], K 000686145 image!, LE 00015634 image!, MEL 7855!, P00115426 image!, P00115427 image!).

*Hydrocotyle blepharocarpa* F.Muell., *S. Sci. Rec.* 3: 175 (1883). *Type:* ‘Upper Swan River’ [Western Australia], 1883, *Miss Julia Sewell s.n.* (*holo:* MEL 7788!; *iso:* MEL 7789!).

*Annual herbs* 1–3 cm high, 5–30 cm wide, with 3–6 basal leaves and branched stems bearing leaves and umbellate inflorescences. *Stems* prostrate to ascending, pale green to yellowish green or reddish green, terete, glabrous. *Stipules* white, lanceolate to broadly ovate, 1.0–2.5 mm long, 0.5–1.2 mm wide, membranous, translucent, irregularly toothed to fimbriate along margins. *Petioles* 4–40 mm long, glabrous. *Leaf blades* simple, dorsiventral, carnose, trilobed to palmatifid, 4–15 mm long, 4–20 mm wide, cordate at the base, glabrous; adaxial surface light green; abaxial surface slightly paler in colour than adaxial. *Leaf margins* toothed; teeth mostly rounded to obtuse. *Median leaflobes* oblanceolate, 3–12 mm long, 3–9 mm wide, with 3–5 marginal teeth. *Lateral leaflobes* 2–11 mm long, 3–11 mm wide, with 2–8 marginal teeth; leaf sinuses 10–40% of lateral leaflet length. *Inflorescences* leaf-opposed, simple umbels, anthesis centripetal, 6–18-flowered, 2–4 mm wide. *Peduncles* terete, shorter than subtending leaf at anthesis, becoming distinctly longer than subtending leaf when in fruit, 2–45 mm long, glabrous. *Floral bracts* linear to linear lanceolate, margins entire to sparsely ciliate, 0.4–0.6 mm long. *Pedicels* light green, subterete, longitudinally flattened, 0.1–0.3 mm long. *Flowers* all bisexual, protandrous. *Sepals* absent. *Petals* 5, pale to dark crimson, ovate, 0.4–0.5 mm long, 0.3–0.4 mm wide. *Filaments* white, 0.2–0.3 mm long. *Anthers* creamy yellow, elliptic, c. 0.2 mm long. *Ovaries* pale green at anthesis, bilaterally flattened, orbicular. *Fruiting pedicels* 0.5–1.2 mm long, innermost pedicels distinctly longer than their subtending floral bracts and the peripheral whorl of pedicels. *Schizocarps* bilaterally flattened, symmetrical, orbicular; bases cordate; mericarps light green turning reddish brown at maturity; commissure 90–95% the length of mericarps. *Mericarps* 0.8–1.0 mm long, 0.6–0.8 mm wide, glabrous or fringed with hairs; dorsal and lateral ribs conspicuous, acute; median ribs raised and swollen at surface; surface between dorsal and lateral ribs concave, glabrous or with bristly hairs on raised surface adjacent to lateral ribs; surface between lateral and median ribs glabrous, slightly concave, scutellate. *Carpophores* absent. *Fruiting styles* slender, c. 0.2 mm long, erect to ascending. *Cotyledons* oblanceolate in the seedlings. (Figure 8)

*Diagnostic features.* *Hydrocotyle scutellifera* can be distinguished from allied species by a combination of the following characters: annual herbs with glabrous stems, leaves, peduncles and pedicels; flowers with crimson petals; orbicular schizocarps with variably hairy outer margins of the lateral ribs (from dense to sparsely hairy or glabrous) and erect to ascending fruiting styles; mericarps with (semi-circular) scutellate lateral surfaces arising from the prominently raised lateral and median ribs; innermost fruiting pedicels (0.5–1.2 mm long) distinctly longer than their subtending floral bracts (0.4–0.6 mm long) and the peripheral whorl of pedicels; and the absence of persistent carpophores (Figure 8).



Figure 8. *Hydrocotyle scutellifera*. A – fertile plants *in situ* during later stages of fruiting, infructescences with glabrous fruit indicated with the red arrowheads; B – infructescence showing mature schizocarps with densely bristly outer margins; C – infructescences following disarticulation of mature mericarps showing fruiting pedicels distinctly longer than subtending floral bracts (yellow arrowhead). Scale bars = 5 mm (A); 2 mm (B, C). Vouchers: PERTH 09078169 (A); PERTH 08502579 (B); PERTH 08840784 (C). Photographs by A. Perkins.

*Selected specimens examined.* WESTERNAUSTRALIA: Yanchep area, 29 Aug. 1965, *A.C. Beauplehole* 12382 (AD, MEL, PERTH); track to Point Nuyts, Nornalup National Park, 2 Oct. 1967, *R.O. Belcher* 329 (MEL); Grevillea Tower rock, Winneup forest block, N of Kingston Rd along North Boundary Rd, left hand side 0.75 km, 8 Nov. 2005, *R.J. Cranfield* 21867 (PERTH); east side of Lake Timperley, Rottnest Island, 4 Oct. 2000, *J. Dodd* 794A (PERTH); at base of Mount Chudalup, 3 Oct. 1976, *Hj. Eichler* 22057 (AD, CANB, NSW, PERTH); Angwin Peak, Porongurup Ranges, 5 Oct. 1976, *Hj. Eichler* 22088A (CANB, MEL, PERTH); Old Coast Rd, N of Bunbury, 23 Sep. 1972, *A.S. George* 11627 (CANB, PERTH); c. 1 km S of junction of Thomas Rd and Johnson Rd, E of Medina, 18 Sep. 1977, *A.S. George* 14908 (CANB, PERTH); Yeagarup Dunes Rd, c. 2.5 km by road from coast, 29 Oct. 1990, *N. Gibson & M. Lyons* 983 (PERTH); rifle range (Reserve 22459), SSE of Port Denison, 29 Aug. 1991, *E.A. Griffin* 6409 (PERTH); Lake Muir, *s. dat.*, *T. Muir s.n.* (MEL 0008286A); south-eastern slope of Devils Slide, Porongurup Range, 29 Sep. 1966, *T.B. Muir* 3945 (MEL); summit of Castle Rock, Porongurup Range, 29 Sep. 1966, *T.B. Muir* 3960 (MEL); Porongurup National Park, along Scenic Drive below Angwin Peak, 20 Sep. 1983, *R. Ornduff* 9326 (PERTH); 200 m W of Lake Unicup, 25 Sep. 2005, *A.J. Perkins s.n.* (NSW, PERTH, SYD); edge of large granite outcrop along Park Rd and below Angwin Peak, Porongurup National Park, 15 Oct. 2007, *A.J. Perkins s.n.* (NSW, PERTH, SYD); large granite outcrop on N side of South Western Hwy, Shannon National Park, c. 1.3 km S of Middleton Rd, 16 Oct. 2007, *A.J. Perkins s.n.* (NSW, PERTH 8048673, SYD); 1.7 km N of Point D'Entrecasteaux, 30 Oct. 2016, *A.J. Perkins* AJP-WA131 (PERTH); south side of Mandalay Beach Rd, 400 m from Mandalay Beach carpark, 30 Oct. 2018, *A.J. Perkins* AJP-WA160 (BRI, MEL, PERTH); south side of Mandalay Beach Rd, 3 km from Mandalay Beach carpark, 30 Oct. 2018, *A.J. Perkins* AJP-WA161 (MEL, PERTH).

*Phenology.* This species is a winter annual, with flowering and fruiting occurring from August to November.

*Distribution and habitat.* *Hydrocotyle scutellifera* is broadly distributed in south-western Western Australia, from Dongara in the north, to Cape Leeuwin in the south-west, through to the Porongurup Range and Albany in the east (Figure 9). Plants often grow in moist, sheltered positions amongst coastal sand-dunes and limestone, or on moist granite outcropping along the coast and in near-coastal areas. Populations with both glabrous and bristly fruits are widespread and are known to occur in the Perth region, as well as the Porongurup Range, Lake Muir and near Mandalay Beach.

*Conservation status.* *Hydrocotyle scutellifera* is a widely distributed and common species. No conservation code applies.

*Etymology.* The epithet is derived from the Latin *scutella*, 'a small shield', and *fero*, 'to bear', in reference to the lateral surfaces of the fruit bearing a 'little shield' on both sides of each mericarp (Figure 8A,B). The prominently raised lateral and median ribs, with the semi-circular concave surface between them, give each mericarp their characteristic shield-like appearance. The common name 'Western Shield Pennywort' is here suggested.

*Affinities.* Recent molecular phylogenetic analyses place *H. scutellifera* s. str. (*syn. H. blepharocarpa*) within a clade of annual *Hydrocotyle* that have persistent floral bracts, referred to as the bracteate annuals (Figure 1). *Hydrocotyle scutellifera* is sister to the freshwater aquatic species, *H. lemnoides* in all phylogenetic reconstructions (Figure 1). Both of these species in turn form a sister relationship with *H. perplexa*. The re-circumscribed *H. scutellifera* is morphologically most similar to *H. perplexa* and can be readily distinguished from it by having crimson petals (white in *H. perplexa*), orbicular



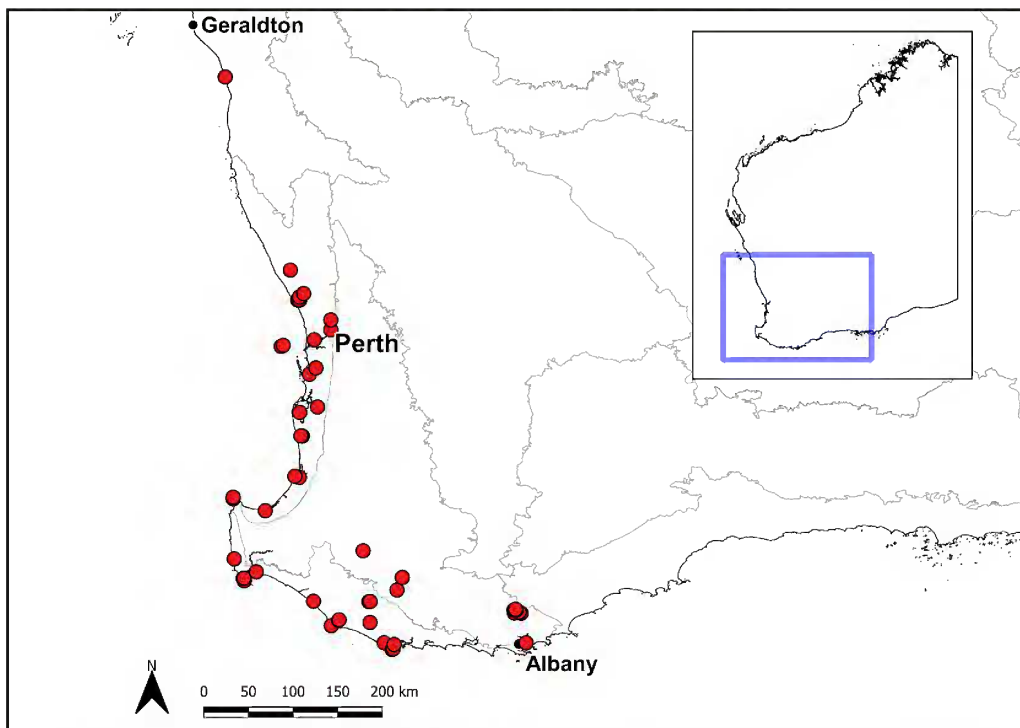


Figure 9. Distribution of *Hydrocotyle scutellifera* (●) based on selected specimens held at CANB, MEL, NSW and PERTH. Map with *Interim Biogeographic Regionalisation for Australia* version 7 bioregions (Department of the Environment 2013) shown in grey. Based on specimen data from Western Australian Herbarium (1998–) and AVH (2019).

schizocarps (elliptic in *H. perplexa*), scutellate mericarp surfaces (shallowly concave mericarp surfaces in *H. perplexa*), floral bracts distinctly shorter than fruiting pedicels (similar in length for *H. perplexa*), erect to ascending fruiting styles (reflexed fruiting styles in *H. perplexa*), carpophores not persistent (carpophores persistent but fragile in *H. perplexa*).

*Typification.* In the protologue for *H. scutellifera* (1867), Benthams cites two collections, the ‘1st Coll. and 2nd Coll. n. 4’ both made by James Drummond. The ‘1st collection’ consists of a single herbarium sheet held at Kew (K 000686144) with two plants, one labelled ‘Swan River. Drummond, 1839’ and the other stamped with ‘Herbarium Benthamianum 1854’. The specimens on this sheet were gathered by Drummond during the later stages of flowering and fruiting, as well as having numerous infructescences in which mature mericarps have disarticulated from their pedicels. The presence of diagnostic features – such as the scutellate (lateral) surface morphology of the mericarps, the innermost fruiting pedicels being distinctly longer than their subtending floral bracts and the peripheral whorl of pedicels, along with the absence of persistent carpophores – make this sheet most suitable as the lectotype (designated herein). Drummond’s ‘2nd Collection, n. 4’ was made in 1843 according to annotations on the nine duplicate sheets located at BM, G, K, LE, MEL and P. The specimens in this gathering are in the early stages of flowering and fruit development, with no fully matured infructescences visible on any of the duplicate specimens. Two paralectotypes each have a single, near-mature infructescence (G 00366946 and K 000686143). The lack of mature infructescences with their characteristic features of fruiting pedicels, particularly with the herbarium sheet held at MEL, contributed to Ferdinand von Mueller’s failure to recognise the affiliation between the (glabrous) scutellate fruit of *H. scutellifera* and the bristly (scutellate) fruit variant he later described as *H. blepharocarpa* in 1883 (Mueller 1883).



*Notes.* The polymorphic fruits of *H. scutellifera* and *H. blepharocarpa*, particularly the glabrous-fruited morphotypes, have historically caused confusion when identifying these species. The syntypes of each species are morphologically indistinguishable, except in the ornamentation of mericarp surfaces, and should be considered conspecific. *Hydrocotyle scutellifera* (Bentham 1867) has priority, thus *H. blepharocarpa* (Mueller 1883) must be placed into synonymy. Perkins (2019a) did not recover any internal structure to his *H. scutellifera* (syn. = *H. blepharocarpa*) clade, so no intraspecific taxa can be recognised at this time.

The recircumscription of *H. scutellifera* (above) makes it apparent that Perkins (2019a) misapplied the name *H. scutellifera* to five samples in his analysis. Those samples are now identified as *H. perplexa*.

**Hydrocotyle tetragonocarpa** Bunge in Lehm., *Pl. Preiss.* 1: 284 (1845). *Type citation*: ‘In arenosis conchyliosis humidis prope lacum insulae Rotenest, 21. Aug. 1839 - Herb. Preiss. No. 2085’. *Type specimens*: Rottnest Island, Western Australia, 21 August 1839, *L. Preiss* 2085 (*lecto*, here designated: MEL 8187!; *isolecto*: FI 014716 image!, G 00366947 image!, HBG 517857 image!, K 000686158 image!, LD 1224030 image!, LE 00015635 image!, LE 00015636 image!, M 0172687 image!, MEL 8183!, P 00115433 image!, P 00115434 image!).

*Hydrocotyle* sp. Hamelinensis (G.J. Keighery s.n. PERTH 02391325), Western Australian Herbarium, in *FloraBase*, <https://florabase.dpaw.wa.gov.au/> [accessed 23 November 2018].

*Annual herbs* 1–4 cm high, 10–50 cm wide, with 3–8 basal leaves and branched stems bearing leaves and umbellate inflorescences. *Stems* prostrate to decumbent, pale green to yellowish green or reddish green, terete, glabrous or occasionally covered with scattered wiry hairs. *Stipules* white, elliptic to broadly ovate, 1.5–3.0 mm long, 1.0–2.5 mm wide, membranous, translucent, irregularly toothed to fimbriate along margins. *Petioles* 2–30(–50) mm long, glabrous or sometimes covered with scattered wiry hairs. *Leaf blades* simple, dorsiventral, carnose, palmatifid to occasionally trilobed in mature leaves, 4–18 mm long, 5–20 mm wide, cordate at the base, glabrous; adaxial surface light green; abaxial surface slightly paler in colour than adaxial. *Leaf margins* toothed; teeth mostly rounded to obtuse or occasionally acute. *Median leaf lobes* oblanceolate, 4–12 mm long, 3–7 mm wide, with 3–5 marginal teeth. *Lateral leaf lobes* 4–12 mm long, 4–14 mm wide, with 2–8 marginal teeth; leaf sinuses 15–50% of lateral leaflet length. *Inflorescences* leaf-opposed, simple umbels, andromonoecious, anthesis centripetal, 6–16-flowered, 2–4 mm wide. *Peduncles* terete, shorter than subtending petioles at anthesis, becoming longer than subtending petioles when in fruit, 2–20(–30) mm long, glabrous or sometimes covered with scattered wiry hairs. *Floral bracts* ovate to lanceolate, 0.3–0.5 mm long, margins entire or irregularly toothed. *Pedicels* light green, subterete, 0.3–0.5 mm long. *Male flowers* peripheral in the umbels, with ovaries not developing into fertile schizocarps. *Bisexual flowers* protandrous. *Sepals* absent. *Petals* 5, white to light cream with light pink to crimson on the adaxial surface towards the apex, ovate, 0.6–0.8 mm long, 0.4–0.6 mm. *Filaments* light cream, 0.3–0.4 mm long. *Anthers* creamy yellow or occasionally crimson, elliptic, c. 0.3 mm long. *Ovaries* pale green at anthesis, ovate to elliptic. *Fruiting pedicels* 0.3–0.8 mm long. *Schizocarps* symmetrical, brown to creamy brown at maturity, heterocarpic, developing into one of two morphotypes, either wingless (four-cornered) or prominently winged, glabrous, at maturity disarticulating entire from the pedicel as the mericarps remained joined to the carpophore and do not separate from each other; dorsal and median ribs conspicuously raised, obtuse; lateral ribs inconspicuous. *Wingless schizocarps* elliptic to narrowly ovate, bases and apices rounded to obtuse, 0.8–1.3 mm long, 0.7–1.2 mm wide; surface between dorsal and lateral ribs convex with a raised, thickened longitudinal ridge between the ribs; surface between lateral and median ribs convex with a raised, thickened longitudinal ridge between the ribs; commissure 100% the length of mericarps. *Winged schizocarps* orbicular to broadly obcordate,

bases rounded to truncate, apices prominently cordate, 2.4–4.0 mm long, 2.5–4.5 mm wide; surface between dorsal and lateral ribs laterally flattened; surface between lateral and median ribs convex; commissure 80–95% the length of the mericarps. *Carpophores* not persistent. *Fruiting styles* slender at the base, 0.3–0.8 mm long, distinctly incurved. *Cotyledons* oblanceolate in the seedlings. (Figure 10)

*Diagnostic features.* *Hydrocotyle tetragonocarpa* can be distinguished from allied annual *Hydrocotyle* species, by a combination of the following characters: flowers in simple umbels subtended by persistent bracts, umbels andromonoecious, with male flowers peripheral to the bisexual flowers (Figure 10B), heterocarpic fruit, with or without wings (Figure 10A–C), mericarps within each schizocarp that do not separate from each other after reaching maturity, and erect fruiting styles with incurved apices (Figure 10B,C).

*Selected specimens examined.* WESTERN AUSTRALIA: Cape Leeuwin, S of Augusta, 7 Sep. 1965, A.C. Beauglehole ACB 12493 (CANB, MEL, PERTH); Fish Creek, 21 Sep. 2008, R.J. Cranfield 23256 (PERTH); east side of Lake Timperley, Rottnest Island, 4 Oct. 2000, J. Dodd 794B (PERTH); Hamelin Bay, 0.6 km E of the end of the road to the jetty, 17 Sep. 1982, H.J. Eichler 23020 (CANB, NSW, PERTH); western side of the Augusta–Hamelin Bay Rd, c. 0.4 km S of the turnoff to Cosy Corner, 18 Sep. 1982, H.J. Eichler 23026 (CANB, NSW, PERTH); lookout between Hamelin Bay and Boranup, 27 Sep. 1985, H.J. Eichler 23737 (CANB, MEL, PERTH); Seal Rocks area S of Tim's Thicket Rd, Yalgorup National Park, 19 Oct. 2003, P. Foreman 403 (PERTH); Ledge Bay, E of Albany, 1 Oct. 1971, A.S. George 11095 (CANB, PERTH); c. 1.5 miles along William Bay Rd from Highway 1, W of Denmark, 2 Oct. 1971, A.S. George 11111 (CANB, PERTH); William Bay National Park, firebreak on W boundary, 25 Sep. 1994, B.G. Hammersley 1158 (PERTH); c. 1.5 km N of Seabird along rough track, 9 Sep. 2001, M. Hislop 2305 (PERTH); 2 km N of Yallingup, Cape Naturaliste, 1 Oct. 1989, G.J. Keighery s.n. (PERTH); 20 km E of Augusta, 1 Nov. 2008, M. Maier MM 801 (PERTH); c. 300 m E of Hamelin Bay carpark, Leeuwin Naturaliste National Park, 19 Oct. 2007, A.J. Perkins s.n. (NSW, PERTH 08048517, SYD); southern headland above Shelley Cove, 1 km east of Cape Naturaliste Lighthouse, 18 Oct. 2011, A.J. Perkins s.n. (NSW 888120, SYD); Jurien coastal lakes N of Leeman, 0.8 km E of Indian Ocean Drive on S side of Coolimba–Eneabba Rd, 9 Oct. 2016, A.J. Perkins AJP-WA 118 (PERTH); Lake Thetis, Cervantes. SW side of the lake, 9 Oct. 2016, A.J. Perkins AJP-WA 124 (PERTH); south side of Mandalay Beach Rd, 2.2 km from South Western Hwy, 30 Oct. 2018, A.J. Perkins AJP-WA 157 (AD, CANB, HO, MEL, NSW, PERTH); south of Lake Serpentine, Rottnest Island, 6 Sep. 1999, E. Rippey 118 (PERTH); 22 km E of Augusta, 1 Nov. 2008, R. Warner & P. Hoffman RW 067 (PERTH).

*Phenology.* This species is a winter annual, with flowering and fruiting occurring from late August to December.

*Distribution and habitat.* *Hydrocotyle tetragonocarpa* is distributed in coastal areas and nearby offshore islands in south-west Western Australia, from Leeman in the north, to Cape Leeuwin in the south-west and eastward to the Albany region (Figure 11). This annual species grows in damp, sandy calcareous soils associated with coastal sand dunes, limestone outcroppings and gypsum lakes (Figure 10D). Populations with both fruit morphs present are known to occur on Rottnest Island, Hamelin Bay, Foul Bay, Bunker Bay and areas around Augusta.

*Conservation status.* *Hydrocotyle tetragonocarpa* is a widely distributed and common species in coastal areas. No conservation code applies.

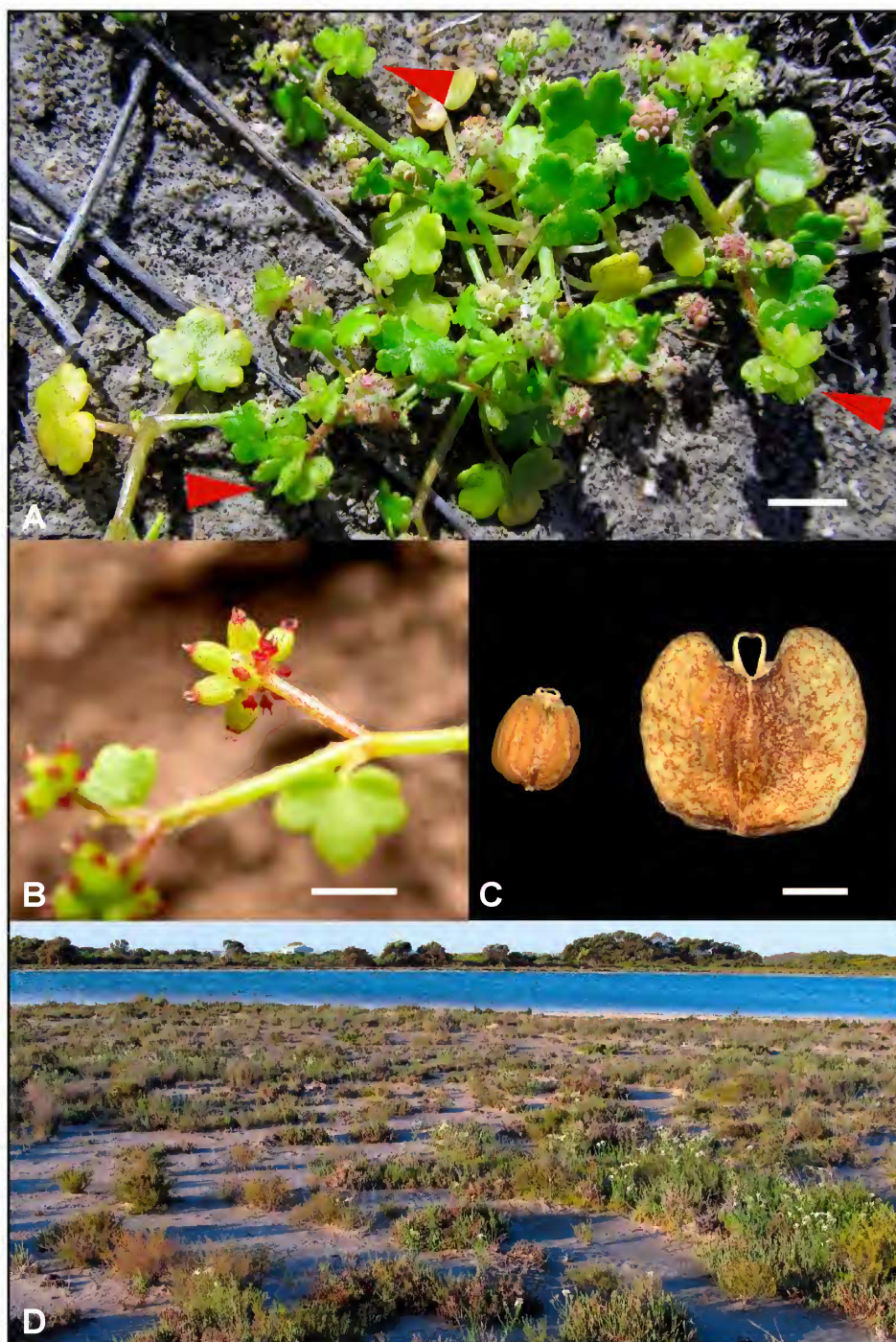


Figure 10. *Hydrocotyle tetragonocarpa*. A—plants with winged fruit morph *in situ* (red arrows indicate infructescences with winged fruits), B—portion of a fertile plant with wingless fruit morph showing andromonoecious umbel; C—mature schizocarps of wingless morph (left) and winged morph (right), D—typical habitat. Scale bars = 5 mm (A, B); 1 mm (C). Vouchers: PERTH 08820872 (A), PERTH 08048517 (B), PERTH 06273211 (wingless fruit) and PERTH 02391325 (winged fruit) (C). Photographs by A. Perkins.



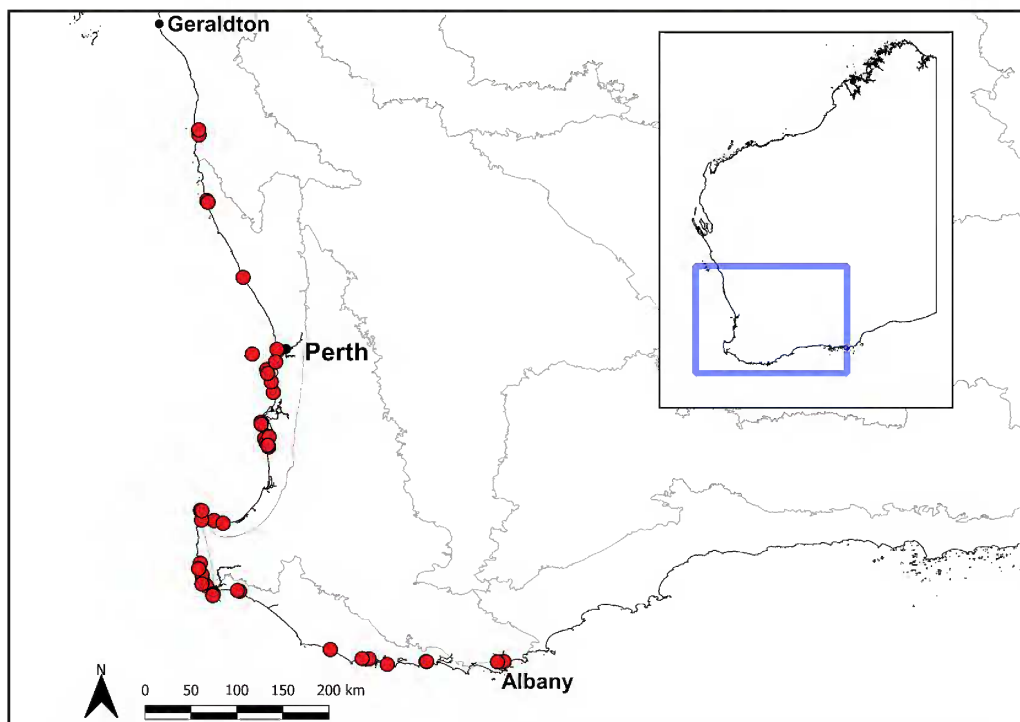


Figure 11. Distribution of *Hydrocotyle tetragonocarpa* (●) based on selected specimens held at CANB, MEL, NSW and PERTH. Map with *Interim Biogeographic Regionalisation for Australia* version 7 bioregions (Department of the Environment 2013) shown in grey. Based on specimen data from Western Australian Herbarium (1998–) and AVH (2019).

**Etymology.** The epithet is derived from the Greek *tetragonus*, ‘four-angled’, and *-carpus*, ‘-fruit’, in reference to the four-angled fruit of the wingless fruit morph (Figure 10B,C). The common name ‘Limestone Pennywort’ is here suggested.

**Affinities.** This species is distinct from all allied annual species of *Hydrocotyle* by having winged and wingless (heterocarpic) fruit. However, it is similar in its vegetative morphology and general habit to taxa such as *H. diantha*, *H. scutellifera* and *H. perplexa*, all of which overlap in their geographic range. Recent molecular phylogenetic analyses (Perkins 2019a) place *H. tetragonocarpa* within a clade of annual *Hydrocotyle* that have persistent floral bracts, referred to as the bracteate annuals. *Hydrocotyle tetragonocarpa* shares these character traits and is sister to *H. plebeia* in phylogenetic reconstructions from combined data analyses of nuclear and chloroplast DNA markers (Figure 1).

**Typification.** MEL 8187 is selected as an appropriate lectotype of *H. tetragonocarpa* as it bears flowering umbels, mature fruit and it conforms to the protologue (Bunge 1845).

**Notes.** Two unusual characters occurring in *H. tetragonocarpa* are heterocarpy and andromonoecy. Heterocarpy is rare amongst members of Araliaceae and previously was only known to occur in populations of *Trachymene pilosa* Sm., in which both heterocarpy and heteromerocarpy are expressed in various combinations, encompassing five distinct schizocarpic variants (Keighery & Rye 1999). In contrast, andromonoecy is relatively common amongst members of the Araliaceae (Schlessman 2010) and has evolved on at least two occasions within Australian species of *Trachymene* (Henwood

*et al.* 2010). However, species of *Hydrocotyle* are regularly reported as being monoecious (Bentham 1867; Henwood *et al.* 2010) and the consistent occurrence of andromonoecy in *H. tetragonocarpa* is now considered novel to the genus (Perkins 2019a).

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